Progress on Microwave Sensors of FY Satellites

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Presentation Overview

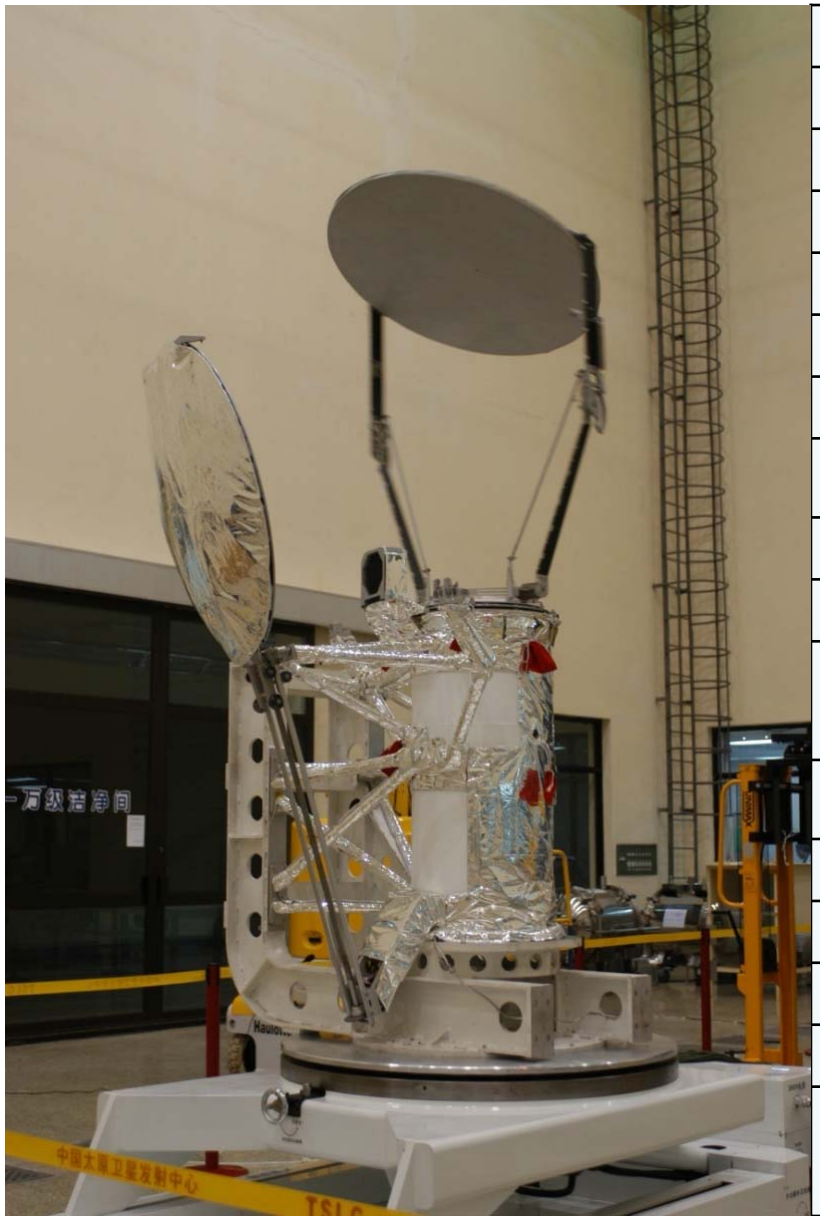
- MW Sensors of FY Satellites
- MWRI
- MWTS
- MWHS
- WindRAD
- Summary

MW Sensors on-board FY Satellites

15 Launched
11 on the Schedule

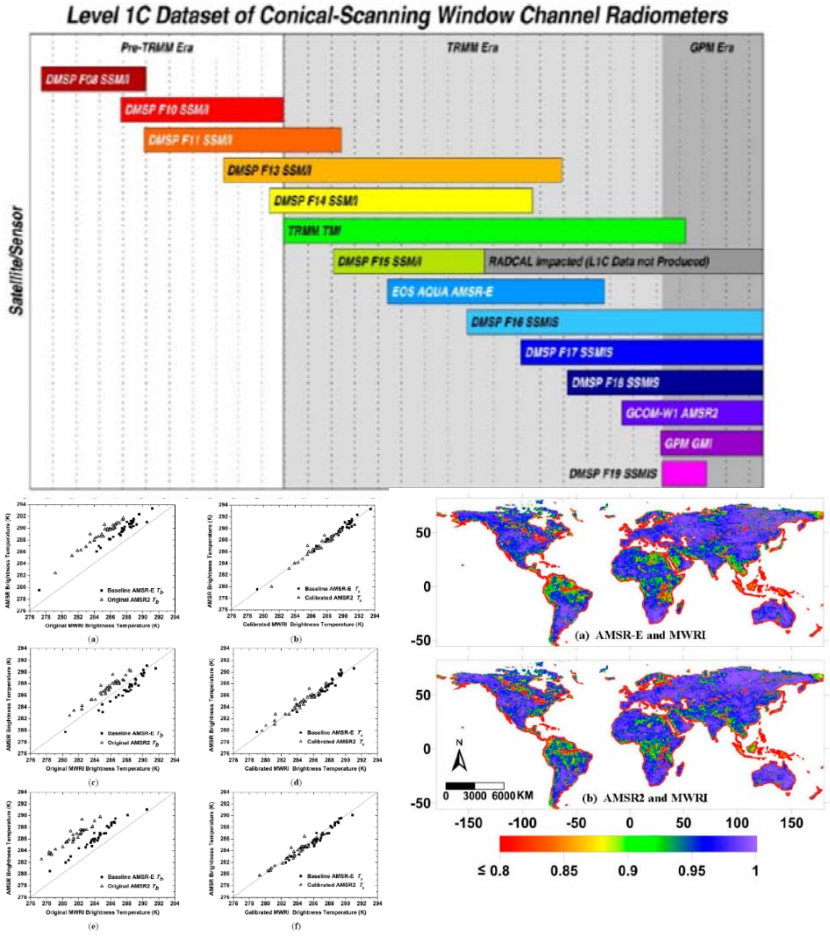
	Passive					Active	
	Imager			Sounder		WindRAD	PR
	MWRI	MWRI-II	MWRI -RM	MWTS	MWHS		
Frequency(GHz)	10-89	10-118	10-183	50.3-57.29	89-183	C/Ku	Ku/Ka
No of channels	10	22	26	13-17	15	2	2
Utilization Period	**2008-2009** **2010-2019** **2013-2020** **2017-**	2022- 2023-	2022- 2025-	**2008-2013** **2010-2014** **2013-2015** **2017-** **2021-** 2022- 2023-	**2008-2014** **2010-2021** **2013-** **2017-** **2021-** 2022- 2023-	**2021-** 2023-	2022- 2025-
Similar Sensors	SSMIS AMSR-E AMSR2	AMSR3	GMI	ATMS	MHS ATMS	ASCAT	PR DPR

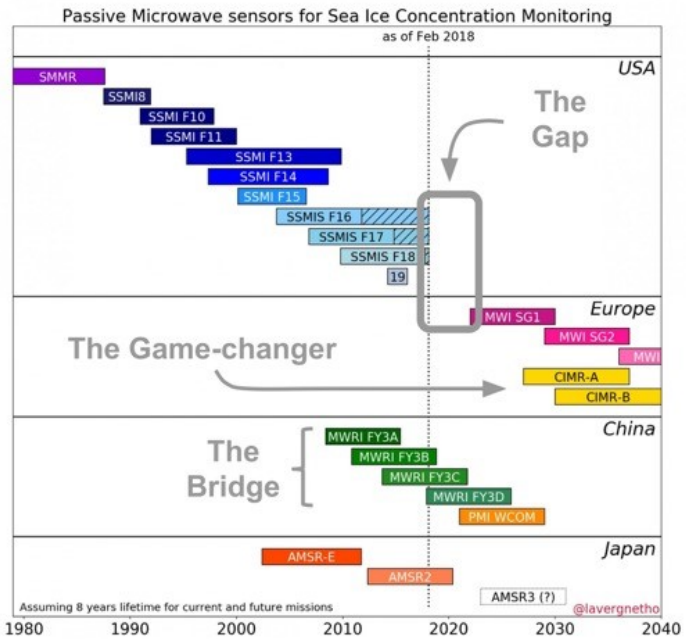
FY-3/MWRI Introduction （A/B/C/D）



Frequency(GHz)	10.65	18.7	23.8	36.5	89
Polarization	V.H	V.H	V.H	V.H	V.H
Band Width(MHz)	180	200	400	900	2×2300
NeDT(k)	0.5	0.5	0.5	0.5	0.8
Accurancy(k)	2.0	2.0	2.0	2.0	2.0
BT Range(k)	3～340				
Scan Points	266(1.8s)				
Black Body Stability	0.3K				
Nonlinear	<1K				
Main Beam	≥90%				
Resolution ≤(km×km)	51×85	30×50	27×45	18×30	9×15
Beam of different Channel	<0.07°				
Scan	Conic				
Orbit Width(Km)	≥1400				
Antenna angle(°)	45				
Scan Period(s)	1.8±0.1（1.7/2.0）				
Scan Period Stability(ms)	≤0.36ms*（2 Scan lines）				
	≤1ms(30 minutes)				

MWRI: Meet the Gap of global climate data record





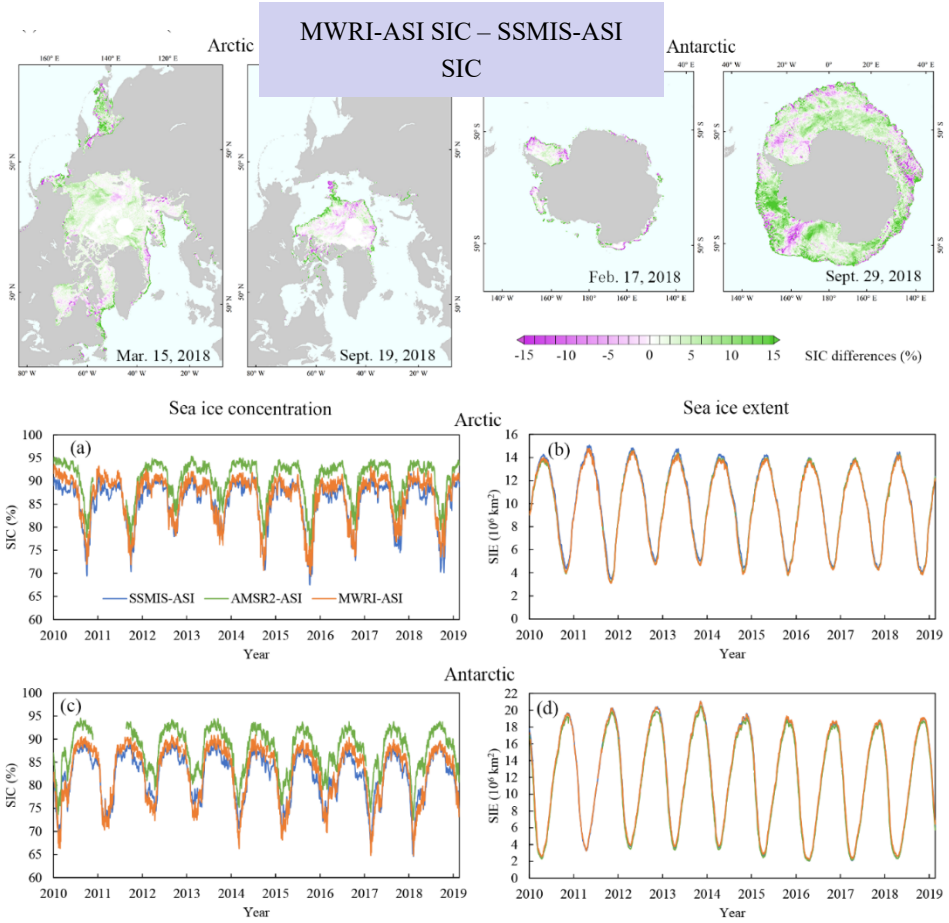
Witze 2017, Nature

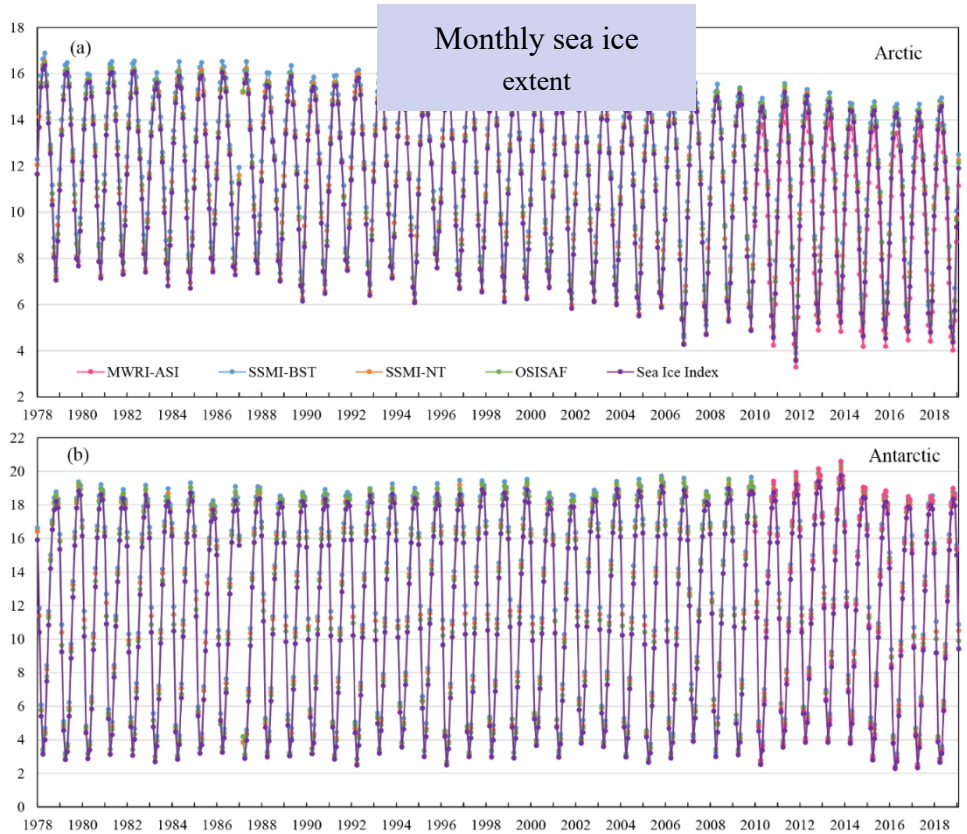
Ageing satellites put crucial sea-ice climate record at risk

FY-3B/C/D MWRI（FCDR）

channel	Typical BT (K)	Mean of RMSE (K)		
		operational	Recal V1.0	Recal V2.0
FY-3B				
10V	166.2	5.00	5.00	1.15
10H	91.8	5.66	5.68	1.21
18V	119.4	1.91	1.87	1.26
18H	127.5	3.12	3.15	1.34
23V	224	2.51	2.46	1.29
36V	223.5	5.76	5.59	0.94
36H	172.1	1.62	2.03	1.10
89V	268.8	2.13	2.19	1.02
89H	248.8	4.24	3.85	1.34
FY-3C				
10V	166.2	5.85	5.85	0.88
10H	91.8	8.12	8.15	0.91
18V	119.4	2.27	2.72	1.07
18H	127.5	2.13	2.13	1.08
23V	224	1.95	1.95	1.10
36V	223.5	3.69	3.69	1.04
36H	172.1	2.87	2.87	1.26
89V	268.8	1.62	1.62	0.88
89H	248.8	1.38	1.38	1.15
FY-3D				
10V	166.2	5.51	5.51	0.91
10H	91.8	6.80	6.87	1.04
18V	119.4	1.32	1.33	0.93
18H	127.5	1.79	1.80	1.08
23V	224	1.41	1.45	1.02
36V	223.5	4.28	4.24	0.94
36H	172.1	4.41	4.39	1.09
89V	268.8	1.64	1.63	0.93
89H	248.8	1.82	1.76	1.33

FY-3 MWRI ASI sea ice concentration





(e)	SIC (%)			
	Arctic		Antarctic	
	SSMI-ASI	AMSR-ASI	SSMI-ASI	AMSR-ASI
Bias	1.1	-4.0	0.8	-4.7
MAD	1.4	4.0	1.7	4.7
Std	1.3	1.4	1.8	1.8
R	0.96	0.97	0.96	0.97

MWRI-ASI SIC has lower difference with SSMI ASI SIC

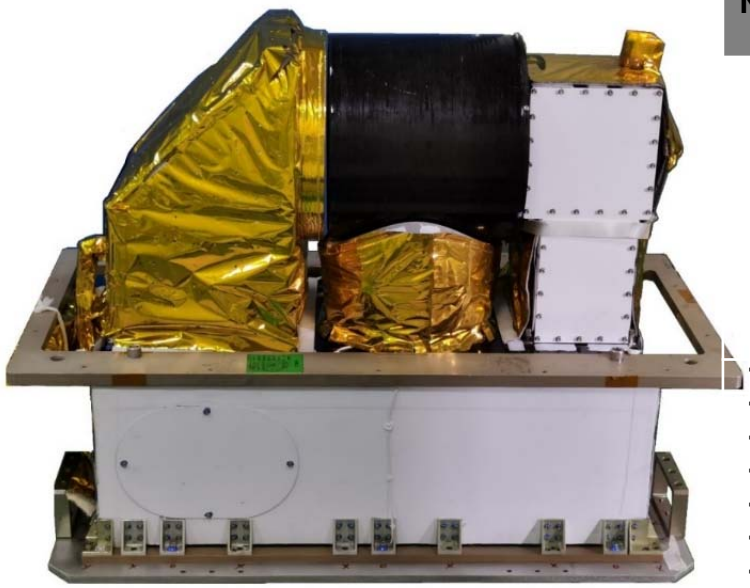
Zhao, Chen, Wu (In prep.)

FY-3E Microwave Temperature Sounder-III (MWTS-III)

MWTS–III is the third generation microwave sounder for atmospheric temperature profiles.

With more channels and higher requirements than before, MWTS-III onboard FY-3E in early morning orbit, can provide valuable data for NWP, climate analysis and other environment studies.

MWTS-III calibration data have been fully processed at the NSMC CMA, since the instrument was turned on July 9, 2021.

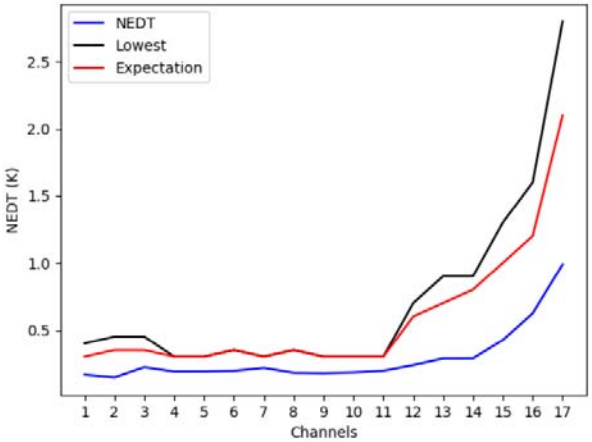


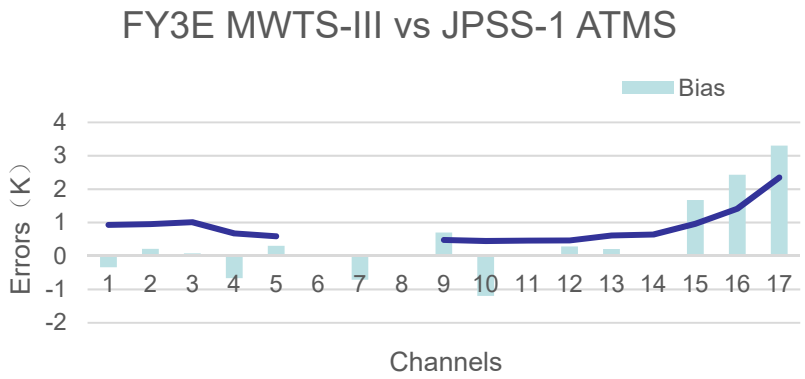
MWTS-III Instrument specifications

No.	Center frequency (GHz)	Band width (MHz)	NEDT (K)	FY-3D NEDT	Main Beam efficient	Polarization
1	23.8	270	0.3		≥95%	QH
2	31.4	180	0.35		≥95%	QH
3	50.3	180	0.35	1.2	≥95%	QV
4	51.76	400	0.3	0.75	≥95%	QV
5	52.8	400	0.3	0.75	≥95%	QV
6	53.246±0.08	2*140	0.35		≥95%	QV
7	53.596±0.115	2*170	0.3	0.75	≥95%	QV
8	53.948±0.081	2*142	0.35		≥95%	QV
9	54.40	400	0.3	0.75	≥95%	QV
10	54.94	400	0.3	0. 75	≥95%	QV
11	55.50	330	0.3	0. 75	≥95%	QV
12	57.290344(fo)	330	0.6	0. 75	≥95%	QV
13	fo±0.217	2*78	0.7	1.2	≥95%	QV
14	fo±0.3222±0.048	4*36	0.8	1.2	≥95%	QV
15	fo±0.3222±0.022	4*16	1.0	1.7	≥95%	QV
16	fo±0.3222±0.010	4*8	1.2	2.4	≥95%	QV
17	fo±0.3222±0.0045	4*3	2.1	3.6	≥95%	QV

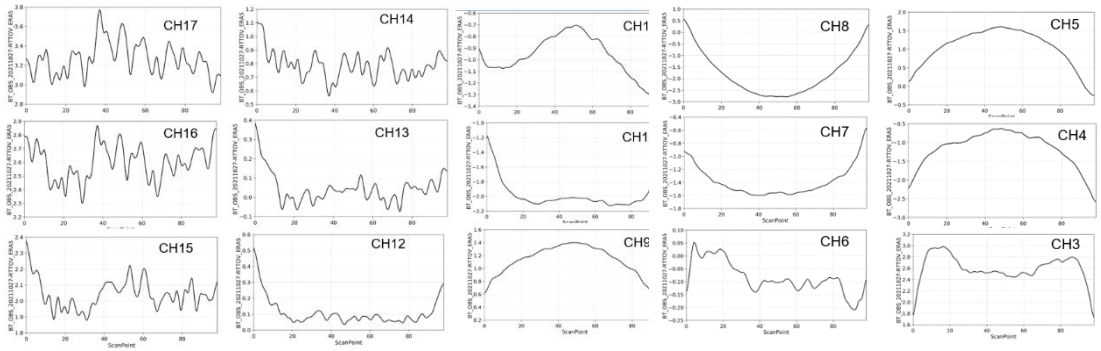
In-orbit Performance of MWTS-III

NEDT

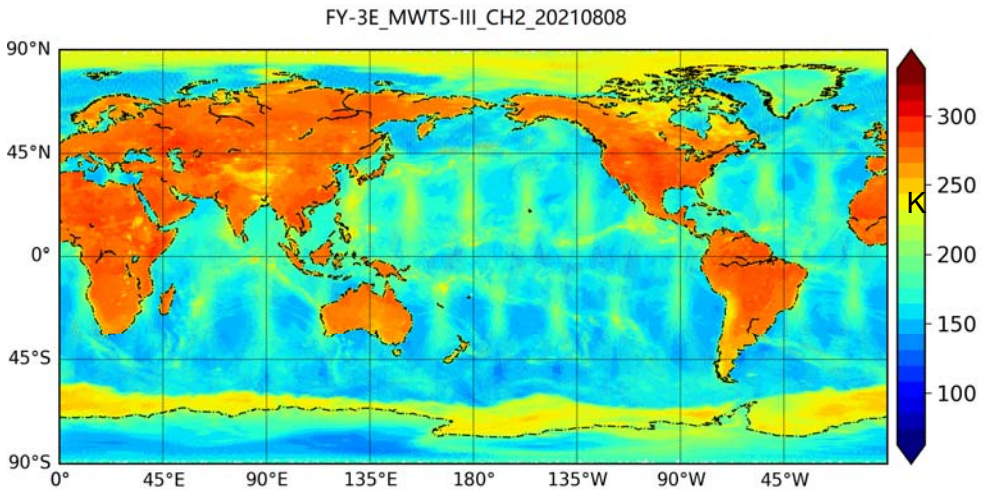




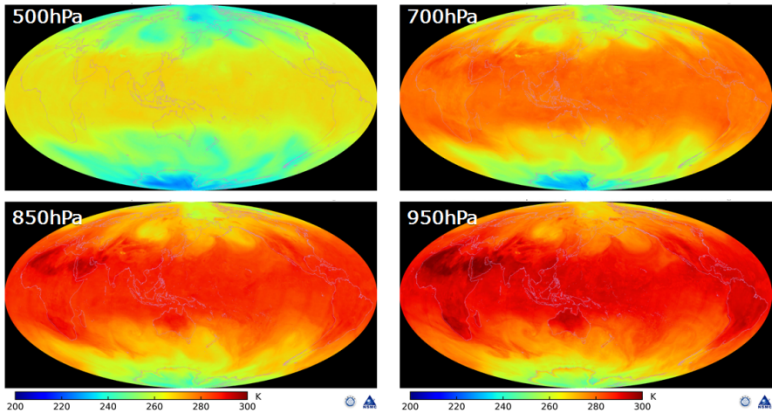
Scan-angle dependent bias

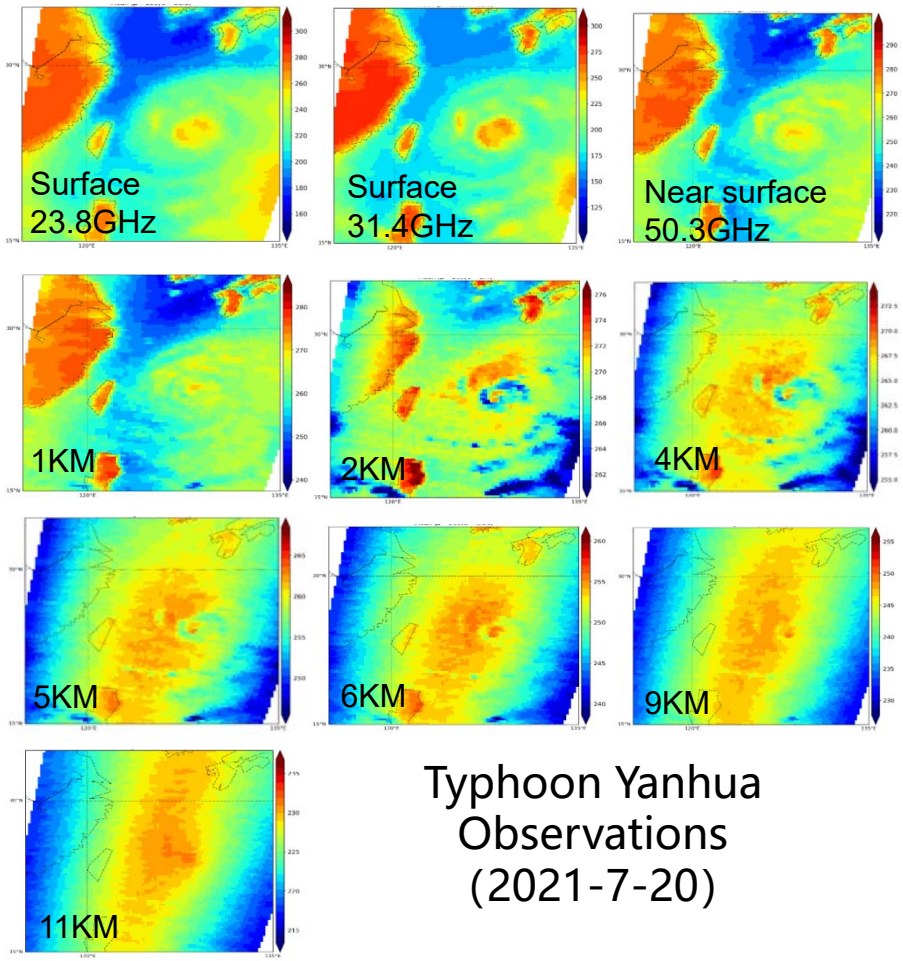


Brightness temperature and L2 product



Vertical section of atmospheric temperature

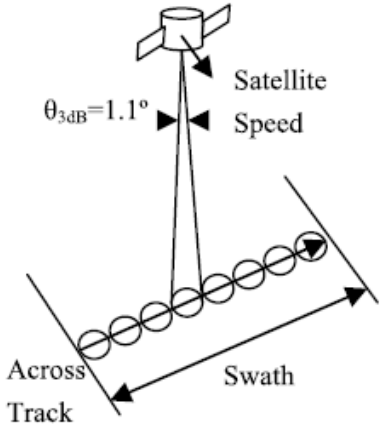




Typhoon Yanhua Observations (2021-7-20)

Microwave Humidity Sounder-II

Instruments Introduction

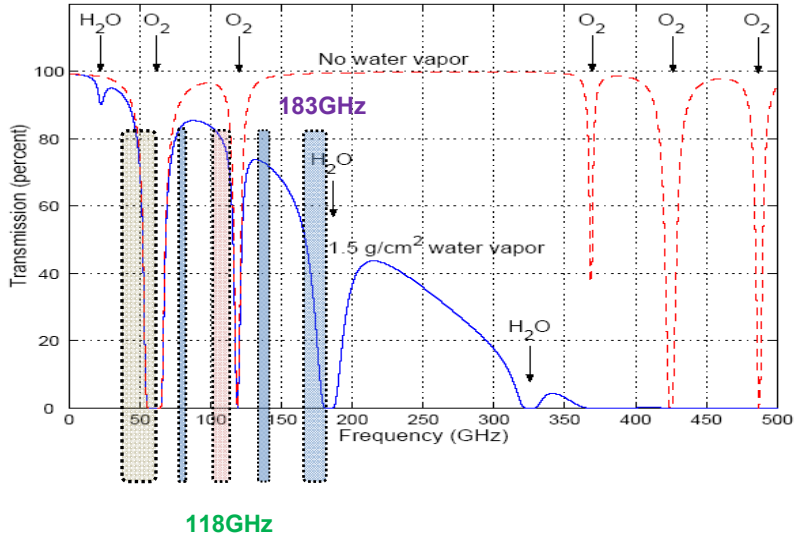


CH	Center Frequency (GHz)	Pol	Bandpass Width (MHz)	Frequency Stability (MHz)		NEDT (K)		Accuracy* (K)		3-dB Beamwidth
				C/D	E	C/D	E	C/D	E*	
1	89.0	V	1500	50	50	1.0	0.4	1.3	1.0/0.8	2.0°
2	118.75±0.08	H	20	30	20	3.6	2.2	2.0	2.4/2.2	2.0°
3	118.75±0.2	H	100	30	20	2.0	1.0	2.0	1.2/1.0	2.0°
4	118.75±0.3	H	165	30	20	1.6	0.8	2.0	1.2/1.0	2.0°
5	118.75±0.8	H	200	30	20	1.6	0.8	2.0	1.2/1.0	2.0°
6	118.75±1.1	H	200	30	20	1.6	0.8	2.0	1.0/0.8	2.0°
7	118.75±2.5	H	200	30	20	1.6	0.8	2.0	1.0/0.8	2.0°
8	118.75±3.0	H	1000	30	20	1.0	0.5	2.0	1.0/0.8	2.0°
9	118.75±5.0	H	2000	30	20	1.0	0.5	2.0	1.0/0.8	2.0°
10	**166.0**	V	1500	50	50	1.0	0.4	1.3	1.0/0.8	1.1°
11	183.31±1	H	500	30	30	1.0	0.6	1.3	1.0/0.8	1.1°
12	183.31±1.8	H	700	30	30	1.0	0.6	1.3	1.0/0.8	1.1°
13	183.31±3	H	1000	30	30	1.0	0.5	1.3	1.0/0.8	1.1°
14	183.31±4.5	H	2000	30	30	1.0	0.5	1.3	1.0/0.8	1.1°
15	183.31±7	H	2000	30	30	1.0	0.5	1.3	1.0/0.8	1.1°

*: requirements/expectation

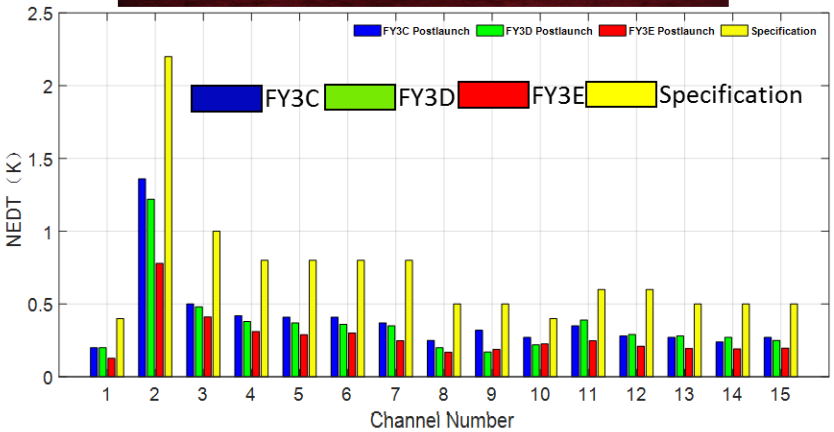
FY-3E MMHS-II VS ATMS/MHS

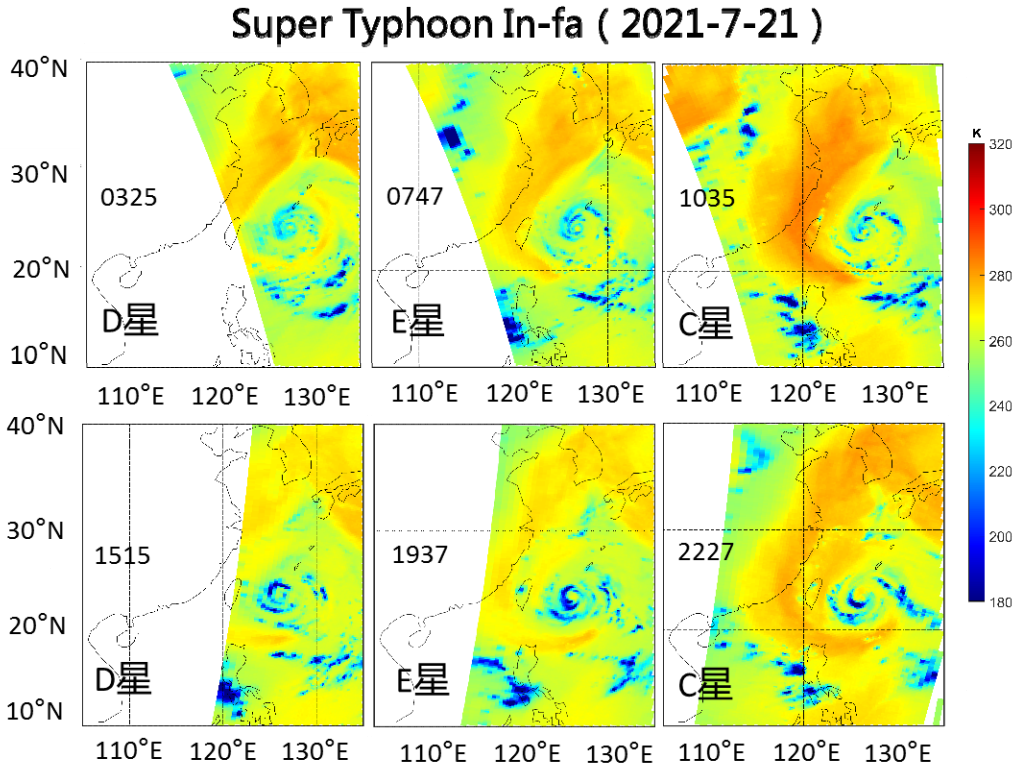
中心频率（GHz）	MWHS-II	MWHS	ATMS	MHS
89.0	1		88.2	89
118.75±0.08	2			
118.75±0.2	3			
118.75±0.3	4			
118.75±0.8	5			
118.75±1.1	6			
118.75±2.5	7			
118.75±3.0	8			
118.75±5.0	9			
166.0	10	150H/150V	165.5	157
183.31±1	11	3	22	3
183.31±1.8	12		21	
183.31±3	13	4	20	4
183.31±4.5	14		19	
183.31±7	15	5	18	5



First space-based Humidity Channel:118GHz

In-orbit Performance of MWHS-II

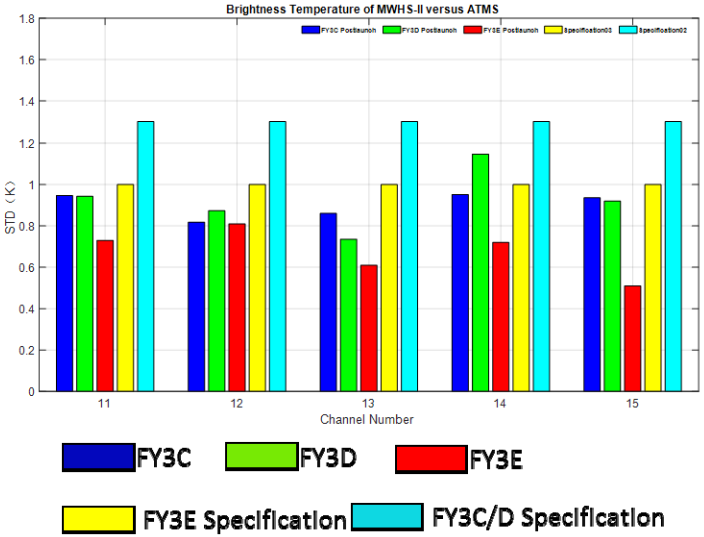




The noise equivalent delta temperature (NEDT) of MWHS-II onboard FY-3 indicates the performance of MWHS-II has been improved gradually from FY-3C to FY-3E

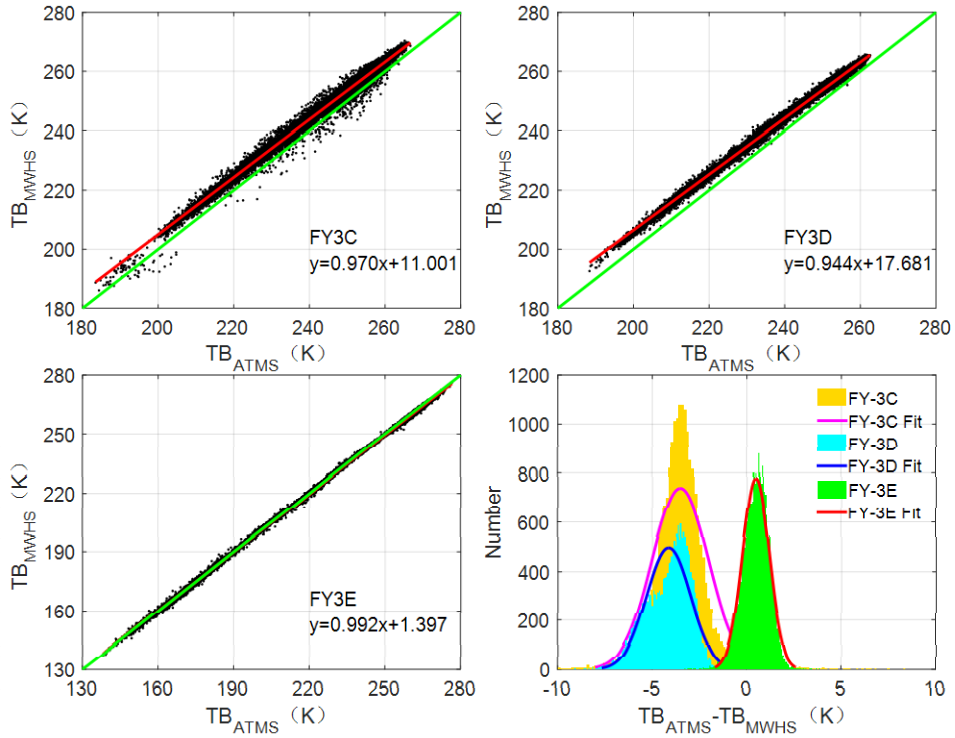
In-orbit Performance of MWHS-II (Continue)

The SNO results



The standard deviations for FY-3E five humidity sounding channels are less than 1K.

MWHS-II .VS. ATMS @ 183.31±4.5 GHz



FY302：
-3.58K/-4.13K

FY3E： 0.46K

FY-3E WindRAD

- **Wind Radar (WindRAD) for Chinese FY-3E satellite**
  - dual-frequency: C & Ku band both with VV & HH polarizations
  - rotating fan-beam
- **SNO for L1 validation**
  - each band, each polarization, each grid resolution or slice data

Metop ASCAT	CFOSAT SCAT	HY-2 SCAT
• C band, VV	• Ku band, HH & VV	• Ku band, HH & VV

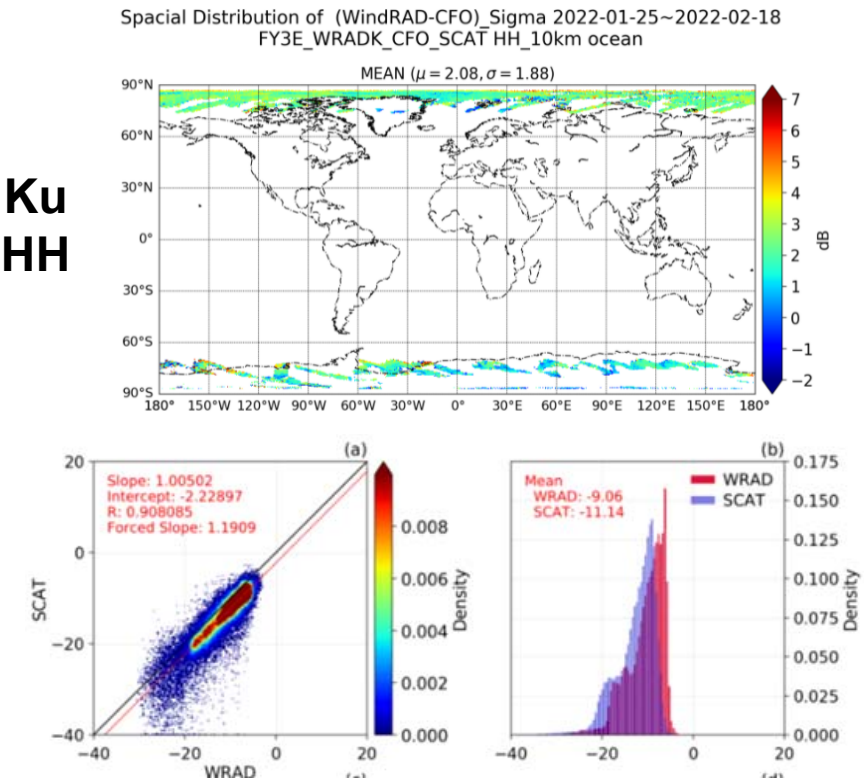
FY-3E WindRAD

Preliminary SNO results:

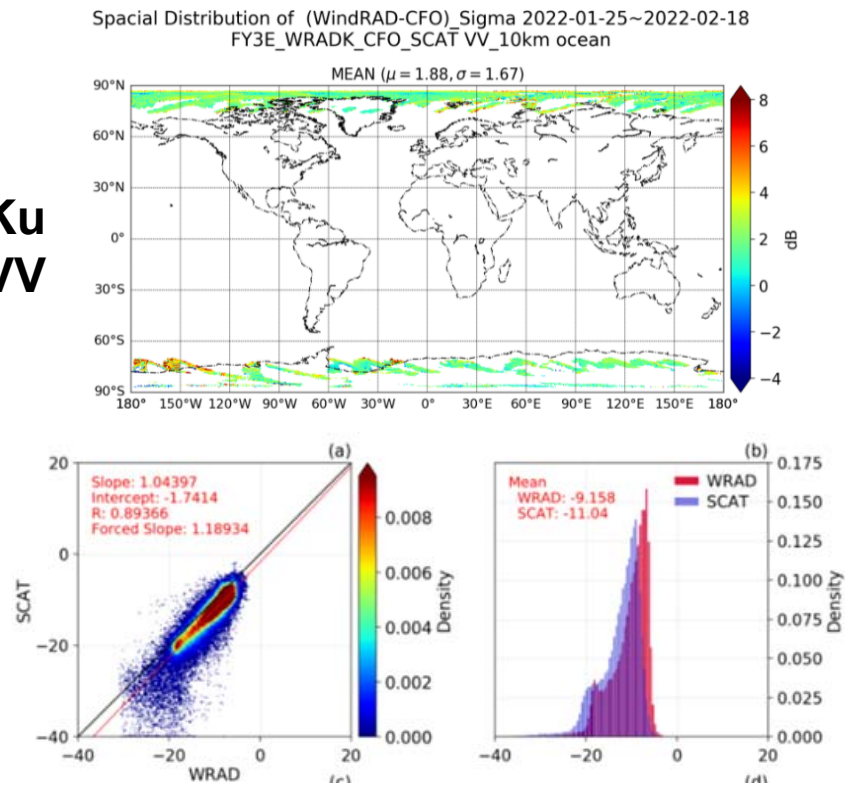
➢FY-3E WindRAD vs. CFOSAT SCAT (WindRAD new version data, 20220125-20220218)

WindRAD vs. CFOSAT Scat	HH 10km	VV 10km
Matching points	176173	186030
Correlation coefficient	0.91	0.89
Mean (dB)	2.08	1.89
Std (dB)	1.88	1.67

Ku HH



Ku VV



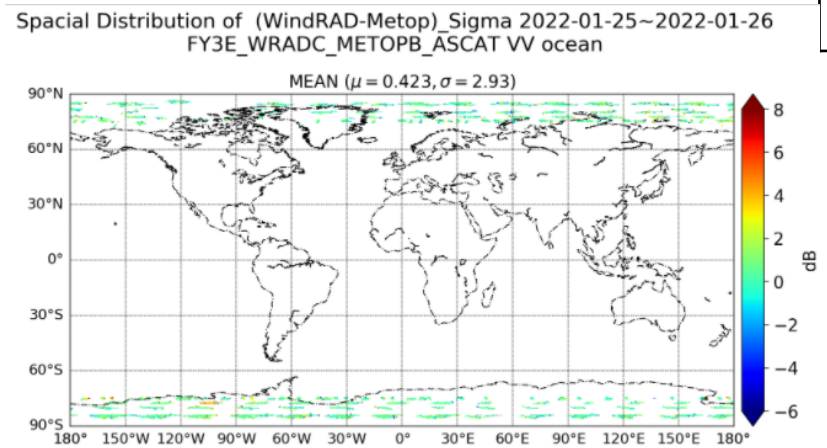
FY-3E WindRAD

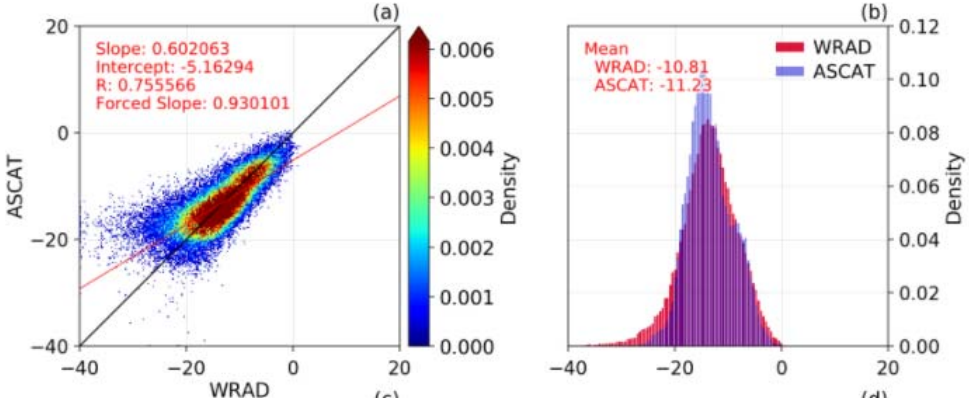
Preliminary SNO results:

➢FY-3E WindRAD vs. Metop-B ASCAT (WindRAD new version data, 20220125-20220126)

WindRAD vs. Metop-B ASCAT	VV
Matching points	56270
Correlation coefficient	0.76
Mean (dB)	0.42
Std (dB)	2.93

C
VV





➢No matching data in February.
➢WindRAD new version L1 data: since 2022-01-25.
➢Waiting for data reprocessing.
➢Sea ice data will be rejected.
➢Quality flag will be used.

Summary

- FY-3D (2017-~) Afternoon orbit
  - MWRI, MWTS and MWHS are in good condition;
  - FCDR of MWRI has been released to some scientific users for evluation;
- FY-3E (2021-~) Early morning orbit
  - Launched in July 5th, 2021;
  - MWHS, MWTS and WindRAD show good performace;
  - In-orbit test of MWHS, MWTS and WindRAD are still ongoing;
- FY-3F (2022-~) Morning orbit
  - Ground test of Flight model (MWRI-II, MWHS and MWTS);
- FY-3G (2022-~) Drift orbit
  - Ground test of Flight model (MWRI-RM and PR).
- FY-3H (2023-~) Afternoon orbit
  - Ground test of Flight model (MWRI-II, MWHS and MWTS)
- FY-3I (2025-~) Early morning orbit
  - MWHS, MWTS and WindRAD
- FY-3J (2025-~) Drift orbit
  - MWRI-RM and PR

FY4-MW (Geostationary MW)
FY5-MW Sensors are under development

Thank you for your attention